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'Acquisition Reform and Best Product Procurement: An Engineering View

ABSTRACT The **military** services are being moved in the direction of performance-based specifications and standards. They are being steered against dictating "how to" produce an item since such action **forecloses** on the ability to gain access to components or technology that may have a commercial equivalent. Why should the engineering community embrace the new approach? Aside from the obvious weight of it being approved **policy,** therefore **currently** mandated, it warrants examination because it is the **correct** approach at this time when applied to appropriate products.

Military specifications and standards are to be displaced then, by acceptable alternative contractor design solutions. Industry bidders will be **allowed** to **propose** the particular design **details, permitting procurement flexibility by** contractually citing only system level or **interface** requirements, both physical and functional. Hopefully **this** *can broaden the* industrial base and increase competition with reduced costs to follow. Conceptually the approach appears both performance-sensible and cost-attractive (there are, of course, consequent risks) but how does implementation proceed? 1s it possible to pursue the goals envisioned abng paths that are not in themselves experimental? Can the American postulate, minimal loss *of life and limb* to U.S. military **people,** continue to be honored? Experience and track record elsewhere imply encouraging possibilities in select situations-useful prospects are **identified** and discussed in practical terms.

Introduction

Acquisition Reform embraces a broad range of activities, from Congressional legislative needs, across cost accounting modifications, through the desire to move toward purchase of more products directly from the commercial marketplace. Clearly, specific aspects of the general package of reforms advanced in the present Administration and Congress impact **scientist/engineer/military** professionals in their approach to design, development, production and operation of warfare systems. Special attention is given in this paper to particular implementation concerns at the working and user levels. The approach offered for coping with the changing culture is based on orderly processes used successfully before, but easily modified to the newly changed circumstances and to be further optimized over time. The paper is not an exhaustive treatment of the subject; in fact, it is expected that several iterations and some years **will** pass while myriad problems that surface are "solved" through successive approximation (an old fashioned technique familiar to seasoned engineers). The purpose of this paper is to report a first-look at some of what appear to be immediate issues affecting the **naval** engineering community in those regions especially accommodating to the changed climate, e.g., electronic hardware. Comments upon the broader problem are offered throughout when appropriate. Other disciplines such as commercial software are not addressed.

The authors have consciously chosen publication in this Naval Aviation issue to emphasize the applicability of *Best Acquisition Engineering Processes (BAEP)* to both ships **(ASNE's** classical tradition) and aircraft **(ASNE's** even more historical **em-**

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He has been involved with several weapon system developments. Among these were the Trident II fire control and navigation systems, the BSY-I Anti-Submarine Warfare System, and the Nay standard computers (UYK44 and EMSP). He served as manager of the Digital Circuits Engineering Branch and was then appointed as manager of the Automatic Test Equipment (ATE) Technology Division. *As manager of the ATE Technology Division, he was responsible for the SP-23 Fire Control System Support Project, the SP-24 Navigation Project, and the Fleet Progressive Maintenance Program (2M/ATE). This* Division was *responsible for selection and application of electronic product technology and for developing fleet test and repair techniques.*

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brace). Indeed, the hardware implications of "acquisition reform" cut across all the services and are, therefore, as universal in nature as the breadth of Naval Engineering (surface, subsurface, air and space). The one unchanging requirement that continues throughout any operational use of military hardware by the United States: ***minimizing loss of life and limb.*** Civil-military integration is feasible only as it continues to satisfy such an axiom. The candid scrutiny generated by ubiquitous television coverage and increasing American intolerance for casualties makes this self-evident truth inviolable. In the rush to greater cost savings we must be smart enough to sidestep the compromise of equipment performance and dependability. The vision must include building and maintaining a "Wartime Navy" which can stand-down to peacetime use. This means having a Navy capable of successfully fighting wars without unwarrantable jeopardizing its warriors.

Background

After much discussion and considerable controversy (not yet over), the Department of Defense (DoD) put *teeth* into its intentions with a Secretary of Defense memorandum in summer of '94 addressing a "new way of doing business" in specifications and standards. [11 This path is linked to Vice President Gore's National Performance Review and moves procurement away from government-unique requirements and toward the commercial marketplace. A summary of particular elements in the SecDef memo is set forth in Figure 1. Direction is also given on configuration control, obsolete specifications, use of non-government standards, reduced oversight, the need for cultural change and steps to produce it. Basically, in an aggressive move to make commercial off-the-shelf (COTS), duaJ-usage and civil-military integration more than glib phrases, a policy agenda has been embraced to release industry from the straitjacket of unneeded specifications and standards. This valiant attempt to save dollars capitalizes on the fact that the commercial marketplace dwarfs that of the DoD and is likely to continue to do so unless a major war occurs.

One of the more hopeful signs is that the new policy is not seen as a panacea by the agents of change—they acknowledge there are isolated cases where some type of MIL SPECS will be needed. A combined approach to use of commercial standards is advocated with unique military requirements acceptable only where absolutely essential. [21 The viewpoint held (that the commercial sector must be tapped and guided toward becoming a unified commercial/military industrial base) seems sound for the times and appears to make good sense where applicable. After all, *there* is substantial room for improvement in current procedures.

Performance-Based Specifications And Technical Talent

While it is not feasible to expect 100% reliance on performance-based specifications (because some military needs cannot be met except by detailed, unique design specifications and drawings), savings and improved operation appear obtainable from vigorous attempts to minimize military-unique requirements. The magnitude of the savings and improvements is, however, a raging controversy with little hard data to resolve the argument. Furthermore, not all products are equal in this regard: electronics hardware is not explosive ordnance. It wouJd be a mistake to underemphasize this point in a headlong rush to comply with the latest perspectives on "eliminating" MIL SPECS. Computer processors and displays are susceptible to progressive change but high thrust rocket motors, nuclear power, HY-100 steel and anti-armor warheads need very careful consideration. Pragmatists understand that problem description or, naming the

The first paragraph states, "To meet future needs, the Department of Defense must increase access to commercial state-of-the-am technology and must facilitate the adoption by its suppliers of business processes characteristic of world class suppliers. In addition, integration of commercial and military development and manufacturing facilitates the development of dual-use processes and products and contributes to an expanded industrial base that is capable of meeting defense needs at lower costs."

While careful to avoid disruption in on-going solicitations or contract negotiations, the policy changes are very clear and even when "waived" in special circumstances by specific Executive action must be in place no later than 180 days after the date of the signed memorandum. Waivers for buying items already in inventory are not required. Waivers maybe made on a "class" or item basis for a period of time not to exceed two years.

Also within 180 days of the memo's date, language is to be in place "to encourage contractors to propose non-government standards and industry- wide practices that meet the intent of the military specifications and standards." Program Managers are reminded that use of specifications and standards listed in DoD Inst. 5000.2 is not mandated, but represents guidance. Specifications during production are limited to first tier references in equipment/product specifications; lower tier references are for guidance only. Management and Manufacturing specs are to be used for guidance only; a plan is called for to support cancellation of these specs/standards, inactivating them for new designs, transferring them into non-government standards, converting them to performance-based specifications or justifying their retention as military specs. Completion is to occur, to the maximum extent practicable (emphasis added), within two years.

FIGURE 1. Selected Aspects of Secretary of Defense William J. Perry's memorandum of *29* June 1994

beast (especially with changed constraints) is distinct from problem solution or, taming it. The actual answers to how a program is implemented and acceptable, safe deliverables are produced is left, ultimately to the engineers not to lawyers or bureaucrats. The idea is to stop telling manufacturers "how to build" and simply deal in performance specifications that stipulate what is required. Since interchangeability and dependabifity are essential to sound logistics, the crucial nature of comprehensive and technically accurate performance descriptions is obvious. Less obvious may be the essential nature of logistics engineering with its direct impact upon reliability and operational availability The importance of combined development teams should be self-evident to all concerned. This means highly educated engineering talent fully conversant with the laws of nature. Training alone won't do.

The scope of the poficy changes upon the DoD acquisition process is displayed in Figure 2. Noteworthy is that the conceptual stages of the acquisition process have always been "performance e-based." The situation change today occurs from advanced development onward (Phase I) where commercial products bought via performance-based specifications are to replace many military unique components. Digesting the magnitude of the accompanying impact will take time. Interestingly, the top level performance specification that is written to reduce military-unique requirements will, after all, itself be a military - unique requirement since no commercial market, in the ordinary sense, has interest in the final combat-related product. Nonetheless, the subsystems and components out of which the completed military entity is constructed often can be built from various commercial items that themselves have been manufactured in accordance with private sector descriptions and standards. Ironically moving to the commercial marketplace is no standardization panacea as anyone even slightly familiar with either computer hardware or software can verify Universal standards are not yet in pface to assure all current notebook computer accessories can easily be pfugged into any computer "on the road" or that the results of any one word processing program can be swiftly assimilated by another.

The issue of repair vs. replacement can also bear mightily on the use of performance-based specifications. Replacement lends itself to a performance-based approach while repair may demand identical components in every part in order to keep stockpiling, maintenance (spares), diagnostic manuals and training from becoming a serious problem. Here again, it is very clear that movement toward performance-related procurement demands very qualified engineering talent, knowledge, expertise and the ability to write technical language succinctly and effectively Furthermore, when not to tread that path requires excellent engineering judgement; attempts to reduce the decision-making to programmatic dogma and mindless bureaucratic rules are doomed to failure. Additionally military units must be self-sustaining. Federal Express will probably not deliver replacement parts from the vendor to the war zone. The engineer (particularly the government engineer) must have knowledge of the COTS item sufficient to develop repair procedures. Repair-replacement decisions also impact logistic chains. "Color of money" (SCN, WPN, O&M, N) implications can influence decisionmaking which should be governed by global logic and total cost. Thus, suboptimization can occur at

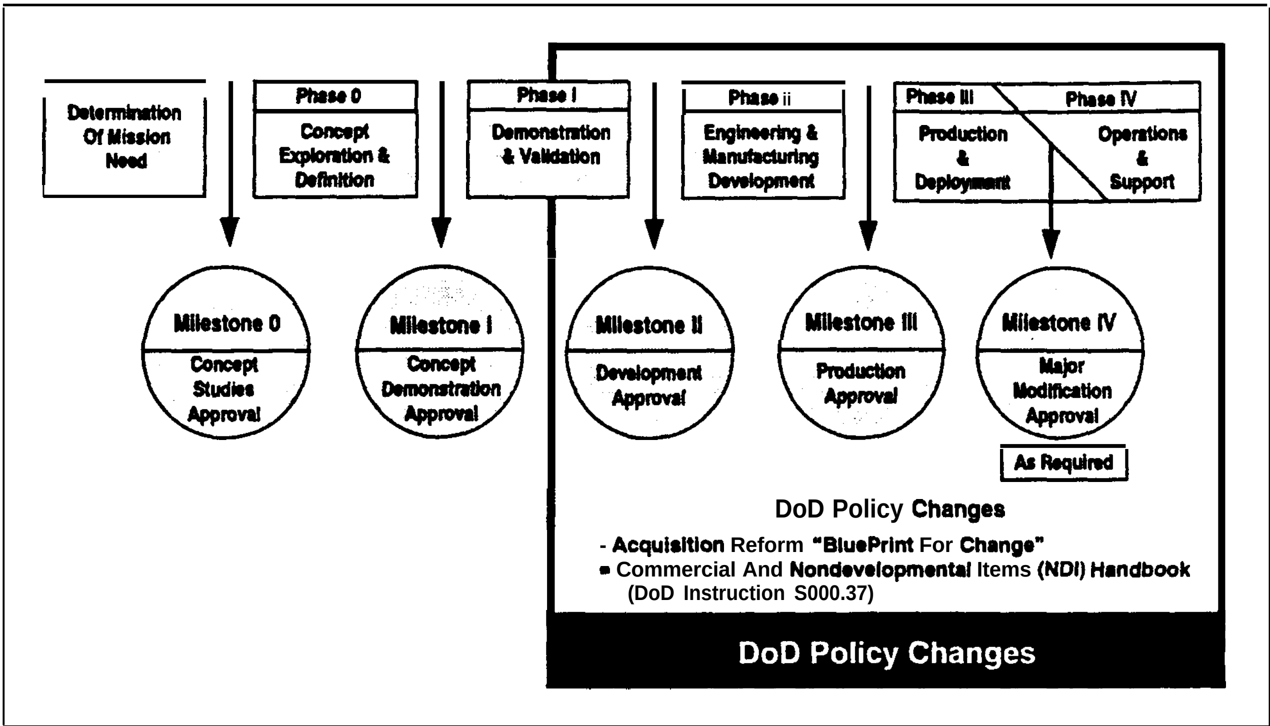


FiGURE 2. Acquisition Milestones & phases

local command levels rather than at more comprehensive Navy levels. Corning to grips with these difficulties is not easy

Given the history of executive intrusion into engineering design matters, the engineering community may feel a sense of irony at this point, but, the final truth is: to the engineer remains the task of building quality products under the new rules. Hard-'me must still meet budget, schedule and performance requirements. Others may pontificate upon the process (they have and they do), but designing and making a working product revolves around engineering activity and accountability. Lawyers, MBA's and political scientists are hard to find when system design decisions have to be made and they are nowhere to be found when accountability for performance is assigned. So, action falls to the engineering professionals wh6 are still actually responsible for successful results in the redrawn technical context. But, the government engineer can't be accountable without knowledge of the design and control of the configuration. The technical challenge is clear, the contractual problem (proprietary rights) is complex.

Best Value Contracting is required to empower the technical integrity needed to deliver specified performance at acceptable risk. Rejection of "low bid" proposals for sound, but sophisticated technical reasons may have to become *more* routine. The procurement system must also be prepared to digest cultural behavior changes. In sum, the new acquisition process requires equipment acquisition engineers and field activity engineers working closely within the commercial marketplace to produce a reliable and supportable product. Previously naval (military) engineers operated primarily as "watchdogs," while the modem role is far more challenging and demands continuing "hands on" engineering talent fully conversant with state of the art hardware and design concepts. The ability of government engineers to sense trouble must be more acute than ever if the procurement process is to avoid being compromised. This means, again, complete conversance with the engineering disciplines and total familiarity with engineering design, manufacture and operation.

Some Navy Electronics Hardware History

About 30 years ago a singular Navy thrust was made to inject order into chaos for electronic hardware at a time when military and space technology demands dominated the commercial marketplace. The approach to reordering the confusion included standardization of interfaces and a process to allow interchangeability of product items with the assurance that system degradation would not occur.

By providing a standard process, market forces could then be allowed to work in a military-industrial environrnent. The Navy Standard Hardware Program (SHP) led to the Standard Electronic Module (SEM) process (Figure 3). This provided a path for individual weapons programs to use existing or to develop new electronic circuit assembly functions which could, in turn, be used by other weapons systems. These items were produced by a variety of manufacturers to performance specifications that allowed them to use their best design and production practices to achieve marketing efficiencies. The government acquisition managers then had multiple sources to choose from thus providing them with the ability to buy quality products at competitive prices. In a world of mostly military unique hardware this initiative allowed for market forces to drive product development and acquisition costs. The accompanying market competition drove down procurement costs many fold while allowing for a responsive product manufacturing base. The SEM program had three main ingredients to allow these market forces to work:

- Use of standardization to guarantee interchangeability
- Use of performance and interface specifications to achieve real competition.
- , Establishment of product verification requirements to ensure that perforrnance, interface match, and quality needed were met.

Standardization of interfaces was achieved by first defining the physical dimensions of the assembly and then its functional interfaces. This allowed physical and electrical interchangeability In a world of little interface standards, the interface connecter to the backplane defined the connection bcation of signal, ground and power pin locations. Further defined were the electrical characteristics of the signal such as drive levels, cross signal noise allocation and power requirements. These definitions provided for interchangeability where one item could be an exact replacement for another. This technique was a precursor to the buss interface specifications of today, e.g., for the cognoscenti, VME or FutureBus +, which provide for interoperability where one item may not be “instantaneously” interchangeable with another but is “compatible” so that it may be “tuned” into an exact replica.

The key to performance specifications at the lower assembly level was to have standard definitions in place. In general, the goal of a performance specification is not only to insure that performance levels are met but that products are exactly interchangeable, both physically and fictionally This resulted in performance specifications with the following attributes:

- Clearly defined description of how the product was supposed to function.
- Clearly defined performance characteristics so the design or manu-

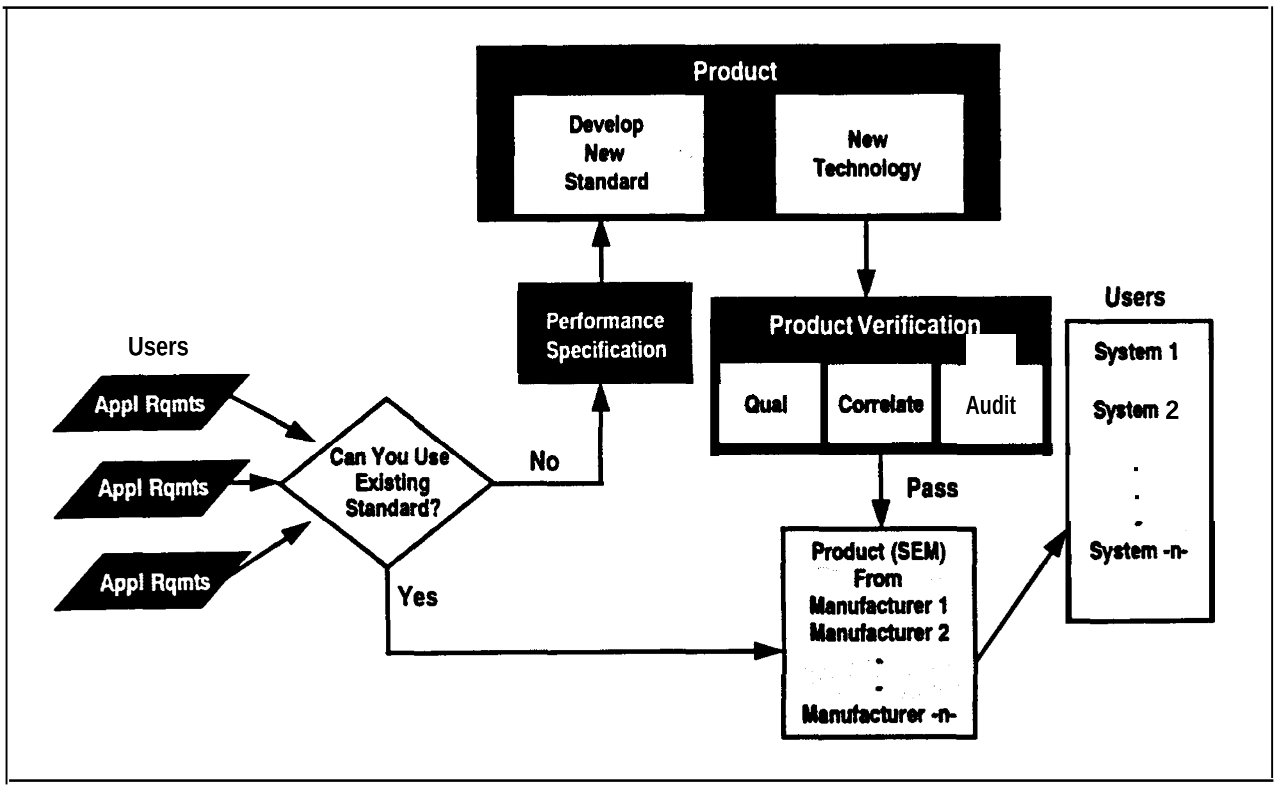


FIGURE 3. Traditional SEM Process

facturing agent could truly relate to them and understand.

- Interface definitions and tolerance bands that provided a high confidence of system interchangeability both geometrical and electrical.
- Appropriate measuring methods defined to provide a common means for both the producer and the buyer to resolve any conflicts with actual vs intended performance.

In generic terms, the specification and its satisfaction can be thought of as a) a comprehensive description of the user environment and b) an established body of data characterizing an item's acceptable response to that environment. This underscores the role of testing and certification as the ultimate insurance guaranteeing that requirements are met.

The next step was to have a disciplined way to validate that the product met and would continue to meet the prospective specification (product verification). To achieve this, three disciplines were applied.

- 'Qualification" was a process that provided an initial and periodic evaluation of the product using the measurement methods spelled out in the specification and assured that the product design and construction met the desired performance requirements.
- "Correlation" provided a method to compare the manufacturer's acceptance test data with the verification agent's data to assure that products accepted at the manufacturer's facility truly met the performance requirements and that the acceptance test methods were repeatable and accurate.
- "Audit" comprised a team of knowledgeable technical personnel m the areas of manufacturing and process control who reviewed the manufacturer's procedures and methods to ascertain that the item was being produced consistency and that procedures were in place to identify and correct defective product or manufacturing methods.

The approach used then was not only flexible but built a track record of achievement over the succeeding years in electronic circuit assemblies, power systems and enclosures that justifies continuing to maintain confidence now in its original promise. The SEM program evolved into the Standard Hardware Acquisition and Reliability Program (SHARP) and the geometrical standards expanded to include multiple "formats" to cope with advancing technology and the growing electronics marketplace, see Figure 4. Injecting uniform standards and a product verification process was the need of yesteryear but the

Ironically, moving to the commercial marketplace is no standardization panacea as anyone even slightly familiar with either computer hardware or software can verify.

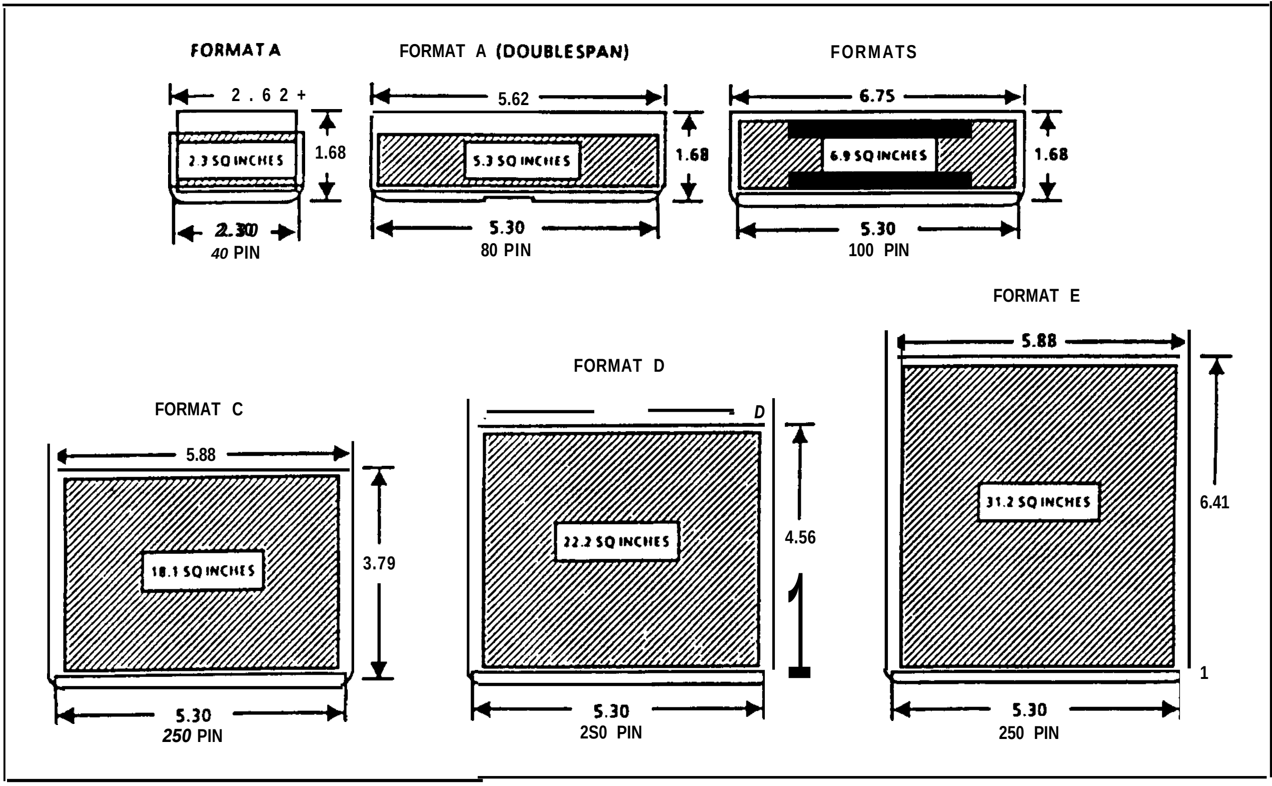
successful process used then is today applicable, with proper tailoring, to commercial off-the-shelf and non-development item (COTS/NDI) purchases. The process continues to work by assuring functional compatibility and controlling product integrity while avoiding unnecessary management intrusion.

Current Circumstances

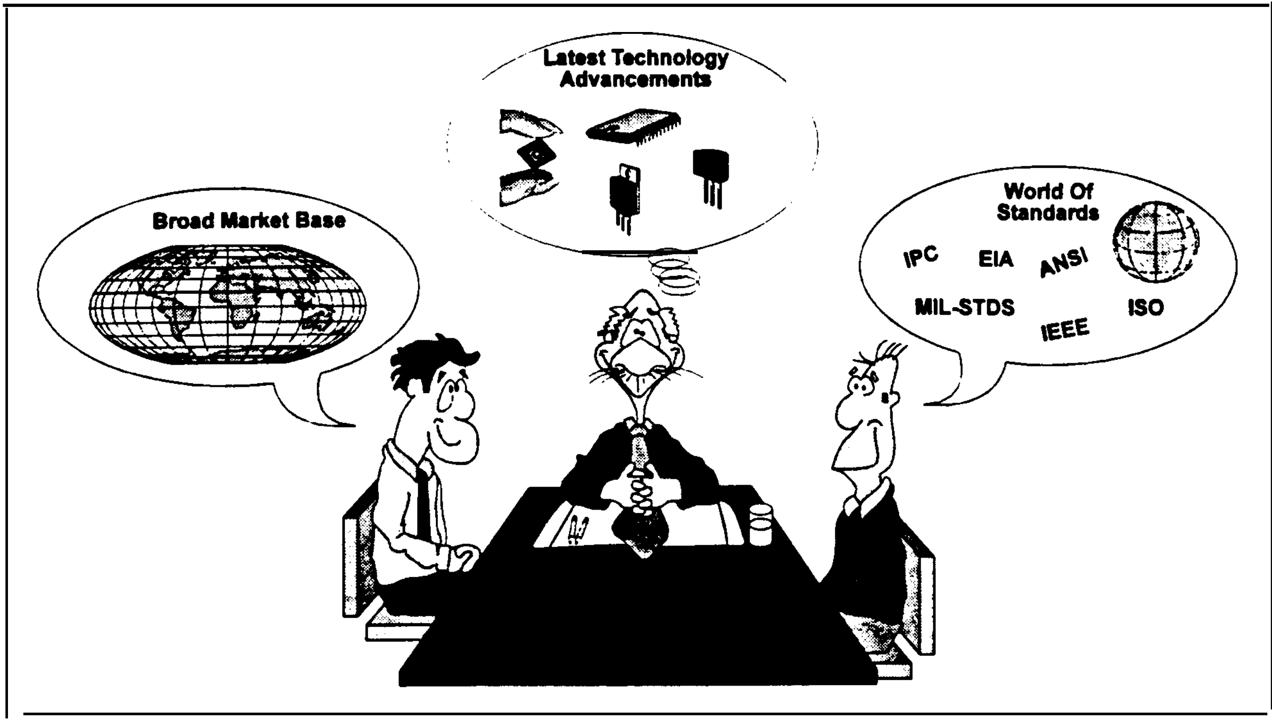
Today, DoD technology leadership is dwarfed by the global commercial product technology market place. A caveat is in order: this observation is true only where a large. commercial market exists. Electronics happens to be an example of a sector with a strong consumer base that also has great military interest. Submarine welding techniques and other military-unique processes and products cannot be treated as simply. Interestingly though, for the hardware that is applicable, the steps necessary to properly implement product acquisition while tapping today's market potential are similar to those of yesterday. There are now just more choices in available technology, standards and market place products (Figure 5). The steps for successful acquisitions, however, still remain:

- Use standard interfaces (do not dictate internal design),
- Cite performance specifications wherever possible (allow state of the art upgrade), and
- Guarantee that the product meets the buyers requirements and expectations (be a "smart buyer," employ technically qualified acquisition talent). This cannot be emphasized enough!

The use of a disciplined approach for using market forces to achieve cost effective technology introduction, as the earlier Navy electronic hardware program did, is clearly not new, but, the sense of urgency within current DoD leadership to shift to a more market based acquisition approach is. The willingness to "get on with it" is now in place at executive levels. This was not present until recently for various reasons. Nonetheless, some very wise engineers wrestled with similar problems in the past and came to grips with parts of the difficulty now being confronted. Truthfully, the process that was developed then was never fully embraced by all hands since no critical need was perceived at the time (conditions were strikingly different) and no relentless budgetary drivers were seen (defense fund levels were rissing). Now, both needs and drivers have changed radically: the reasons for the defense reductions may be po-



F I G U R E 4. SEM Form Factors



F I G U R E 5. *More* Choices

litically arguable on the world stage but the current DoD fiscal reality is clear at this time.

To institutionalize this desired performance-based approach toward design it is essential that Navy RFP's and contracts not include non-value added requirements, yet, still leave Navy the-ability to know quantitatively, what it is buying. Thus. solicitations must minimize the use of military specifications/standards and invite contractors to propose solutions to advertised procurement problems based upon meeting performance-based needs. The existing system with its "cultural" momentum, comfort with the familiar, tendency to avoid risk, and attachment to exhaustive citing of references usually cascades these behaviors into excess, just to make sure "everything is covered." Navy-wide policy will have to call for severe reduction in such tiering of specifications. Real user needs must be identified and isolated so unnecessary reference lists of specifications do not impose unneeded costs and complexity. The problem, however, is that over the years actual user requirements have, in a sense, percolated into and have been buried within the military specifications themselves. In essence, both user and acquisition manager have come to depend upon the specifications to cover certain aspects of the requirement. A burning question arises: What happens when the specification is gone? Clearly, there is a consequent need to make visible the mandatory requirement(s) which competing contractors must then design to meet. This means a "balance" must be struck between military-unique needs and others that can be met by commercial standards. In short, there are continuing judgements to be made requiring special attention and sensitive deliberation. Superior technicaf capability is needed both in government and industry

The existing standardization process stems from a period in DoD acquisition when emphasis was upon rigid adherence to control; certainly in those 50 years, maturity cycles were not measured in months (as in each generation of today's computer and electronics developments) but in years. Worshipping at the altar of detailed, "cast in concrete" specifications in the face of today's rapid generational change assures loss of technical currency, which is then compounded, because it leads toward further avoidance of non-governmental standards. This occurs in order to provide spares to old equipment that demands absolute congruence of parts. In some military equipments, no commercial counterparts ever exist so conscious effort to adaptivity by Navy technical professionals is crucial to the eventual evolution of non-governmental standards adequate for the job. To that end, participation with industry and professional association standard-setting groups must occur.

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This is a difficult and time consuming task. But, current policy encourages just such involvement. [1,2] Funding sources, however, remain unclear.

Today's commercial manufacturing systems incorporate (carefully) product-engineered designs whose quality andperformance are assured through statistical process controls. In contrast, the government has frequently taken an "inspection 'til exhaustion" approach to checking quality in a futile attempt to inject quality almost *ex post facto*. Modern process control techniques (known and taught for many years in both production engineering and business courses) and commercial standards (e.g. 1S0 9000) are realistic paths to reducing costs and improving quality. Navy acquisition personnel must actively embrace these concepts in their daily practices. Other techniques well known for their efficiency and effectiveness in production and operations management, include continuous evaluation, simulation, environment testing, dual-use test facilities, process controls and continuous process improvement. They are in place in many commercial factories and manufacturing firms. Commercial manufacturing practices, however, are dictated by customer quality demands. The recent advance of American automobiles in wresting marketshare from the Japanese underscores the truth of this perspective. The military too, will have to define its quality requirements by its user demands not merely by citing a generic standard, even if "internationalfy" endorsed.

AUTOMOBILES, SEMICONDUCTORS AND COMMERCIAL ACQUISITION CONTROL

In the past the semiconductor vendors supplied parts to the automotive industry under the requirements set by each of the automobile companies. This method of doing business is about to change. The three major automobile vendors, Chrysler, General Motors, and Ford have decided to unite to form the "AUTOMOTIVE ELECTRONICS COUNCIL." This council recently released two documents which set the standards for any semiconductor they wish to purchase. Since there is no definition of what a commercial semiconductor actually is, many people believe that commercial must be what they use in the automotive business. "Commercial," however, may be in the eye of the beholder.

The Automotive Electronics Council's documents addressed quality control of their vendors. The first document is "QUALITY SYSTEM ASSESSMENT FOR SEMICONDUCTOR SUPPLIERS." The document provides interpretation, assessment and implementation guidelines for the semiconductor suppliers. To those familiar with military semiconductor requirements this document is the automotive industries' version of MIL-M-3851O. The second document is "'STRESS TEST QUALIFICATION FOR AUTOMOTIVE-GRADE INTEGRATED CIRCUITS." This document defines the minimum stress test conditions for qualification of integrated circuits. The automobile industry lists three different temperature grades of integrated circuits they require. These grades are as follows:

GRADE 1: – 40°C TO + 125°C
GRADE 2: – 40°C TO + 105"C
GRADE 3: – 40°C TO + 85°C

The automotive document does allow 1S0-9000 certification to suffice for the basic requirements in several areas. However, the auto industry does not buy a part from just any semiconductor vendor producing the function they need. Controls are placed to assure quality and reliability from the available sources. They have further banded together to provide a unified front to the component industry very similar to the MIL SPEC atmosphere. In automotive "COTS" then, there is liberty but not license. Detroit intends to maintain some semblance of control over the inevitable tradeoffs among design latitude, performance, and affordability

ILLUSTRATIVE EXAMPLES

Currently, numerous separate initiatives are being pursued in individual Navy programs which embrace the use of non-developmental commercial items in military systems. These initiatives range across:

a) developing new items using best commercial practices,
b) using COTS items but repackaging them to survive in a military environment. and
c) using COTS items with no modification

The knowledge gained from the applications already being pursued in all parts of Navy and DoD acquisitions will help provide both rules of the road and lessons learned for improved implementation in the future. The following case studies, contributed by working engineers, illustrate the breadth of application for which COTS approaches are underway. These examples, while offering practical illustration and useful engineering insight, also underscore, as ***individual*** thrusts, the benefits that would flow from a coordinated, ***unified process*** based upon sound engineering principles.

CASE STUDY 1
Advanced AN/AYK-14 Standard Airborne Computer, SEM-E Version

The AN/AYK-14 (V) is the designated Navy Standard Airborne Computer System for Naval Aviation. This computer system based upon standard plug compatible modules is capable of growing and satisfying any computing requirement through the foreseeable future. The computer system is designed to provide flexibility and permit different system configurations without system redesign or modification. Off-the-shelf microelectronics technology is used to implement a building block approach that allows a variety of technology infusions and keeps pace with evolving processing needs. The Advanced AYK-14 continues the thrust of the AYK-14 Program by reducing development time and cost through use of commercial-off-the-shelf (COTS) microprocessors, backplane interconnects, MultiChip Modules (MCMs), and commercially defined form factors (Figure 6).

Situation:

A Standard Electronic Module Format E (SEM-E) Advanced Computing effort was initiated to investigate and demonstrate the use of commercial off-the-shelf products and components using best commercial practices to provide state of the art performance processing for the Navy's Fleet. Starting with the AYK-14 System Segment Specification, a performance and interface based requirements document, a multi-disciplined team of engineers developed an approach based on the Standard Electronic Module (SEM) program development and qualification philosophies, best commercial practices of modeling, simulation and test, and COTS components and products. The combined approach included the following:

- Start with a performancee and interface based requirements document.

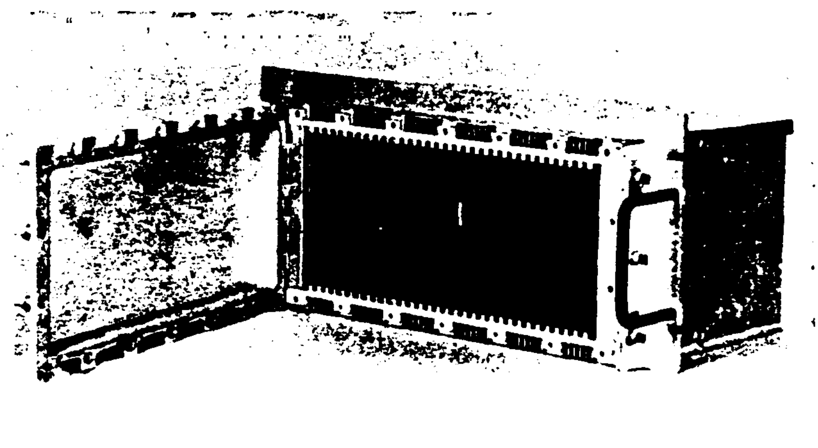

FIGURE 6. AYK-14

- Apply widely accepted commercial open systems interface standards (physical and electrical).
- Develop minimum acceptance criteria.
- Select off-the-shelf components and products available for dual use.
- Team with established industry suppliers.
- Leverage both commercially available items and industry Independent Research and Development (IR&D) efforts through joint agreements.
- Develop weapon system unique products in accordance with selected commercial standards.

Solution:

The solution was to design a system based upon industry accepted standards supported by multiple industry suppliers. The functional designs included as many dual-use components as possible. This provided optional hardware implementations based on the degree and class of environment the system would face in the field without resulting in over-design or the added costs of multiple designs.

Lessons Learned:

1. Get to know the supplier's base products and processes to understand the initial availability, life cycle and quality of the COTS product selected. (This also means that the government equipment engineer cannot have equipment selection based solely upon, or even dominated by, the "low bid.") Define logistics strategy at the same time the COTS product is selected. Asking manufacturers to change their standard product to meet single customer requirements is sure to bring on major problems and costs. Try to use the standard product without alteration.

2. The government is not in the position to be a major part of the commercial supplier's market. Therefore, to establish a pin for pin equivalent military qualified component is the decision of the supplier. A number of component suppliers are bringing their commercial lines up to Qualified Manufacturers List (QML) standards and some are having them approved.

3. Stick with industry accepted interface standards. ***Make sure the standard is accepted and really used by the industry*** Do not use the options in the standard unless they are afso accepted and available from multiple vendors. Look for opportunities with vendors that have both military and commercial product lines and products.

4. Document hardware baseline requirements and the operational environment as early as possible including minimum acceptance criteria.

5. Users wanting multiple vendors must design their system architecture around physical and electrical interfaces that allow the use of multiple parts and items from different vendors.

CASE STUDY 2
Trident Missile Fire Control System

This system provides launch control and initial fight data to the Trident Fleet Ballistic Missile (FBM) carried aboard the Navy's SSBN nuclear ballistic missile submarines.

Can the American postulate, *minimal loss of life and limb* to U.S. military people, continue to be honored?

Situation:

The Strategic Systems Programs (SSP) office is moderately conservative in approach to design and development of systems. Components going into the fire control system are thoroughly documented and certified to meet a stringent set of requirements. (Nuclear safety is the driver.) Still, the tire control system is aging and components are becoming obsolete. One alternative SSP has applied to compensate for this is to use functional replacements of subsystems with commercial}. available hardware.

The Fire Control Branch initiated an off-the-shelf project (COTS/NDI) to investigate the use of readily available hardware to replace obsolete components. A team was composed to develop a commercial technologies philosophy, to identify subsystems that could possibly use off-the-shelf products, and to proceed integrating commercial items into the architecture. The philosophy:

- adopted open systems interface standards that are widely accepted and used by industry
- maximized the use of off-the-shelf products.
- assured that the selected products are built in accordance with the standards selected and comply with them.

Products used included MOTS (see definition below, under BAEP) computer products such as central processing units, input/output cards, and COTS mass storage devices. The COTS replacement was for an obsolete and unprocurable mass data storage system. This item could be replaced with modern personal computer type hard disk drives with one tenth the size and six times improved capacity (Figure 7). A performance specification was developed and acceptable products were identified and tested. The approach was to improve the commercial environmental specifications through use of isolation techniques to meet the SSBN environmental extremes, repackaging the drive in a hermetic case and enclosing it in a mounting structure which then mitigated the shock, vibration and pressure effects (Figure 8).

As might be expected, new challenges occurred when using commercial personal computer products. In

FIGURE 7. Disk Drive

the time it took to do initial market surveys, evaluate products, and develop an alteration to the current system (less than six months), the disk drive technology had changed and many of the evaluated products were no longer available for production procurement. In short, the disk drive manufacturer changed the model of the drive (to make it "better"), and no longer manufactured the same disk drive. This is marketplace reality today with which any practical process expecting to use COTS products must cope.

Solution:

SSP recognized that a variety of factors have to be accounted for when processing off-the-shelf products. One, the disk drive manufacturers constantly upgrade their products to compete in a much larger, constantly changing market. Two, the life of a typical disk drive model is measured in months before it is upgraded to add capacity increase speed, or reduce size. Three. vendors are always trying to increase market share. Four, manufacturers are geared to meet a functional interface, such as Small Computer System Interface (SCSI), and do not concern themselves with "lower level" electronic problems. SSP found that they must act quickly and stay abreast of the market, while keeping their electrical interfaces functional and in-line with accepted industry standards. Otherwise, procurement and integration problems could result. The current buy is projected to last about a decade or more.

Lessons *Learned:*

1. Understand the life cycle of the COTS product selected. Act quickly for the market changes rapidly on most COTS products. Define the logistics support strategy for the COTS product selected before procurement takes place.

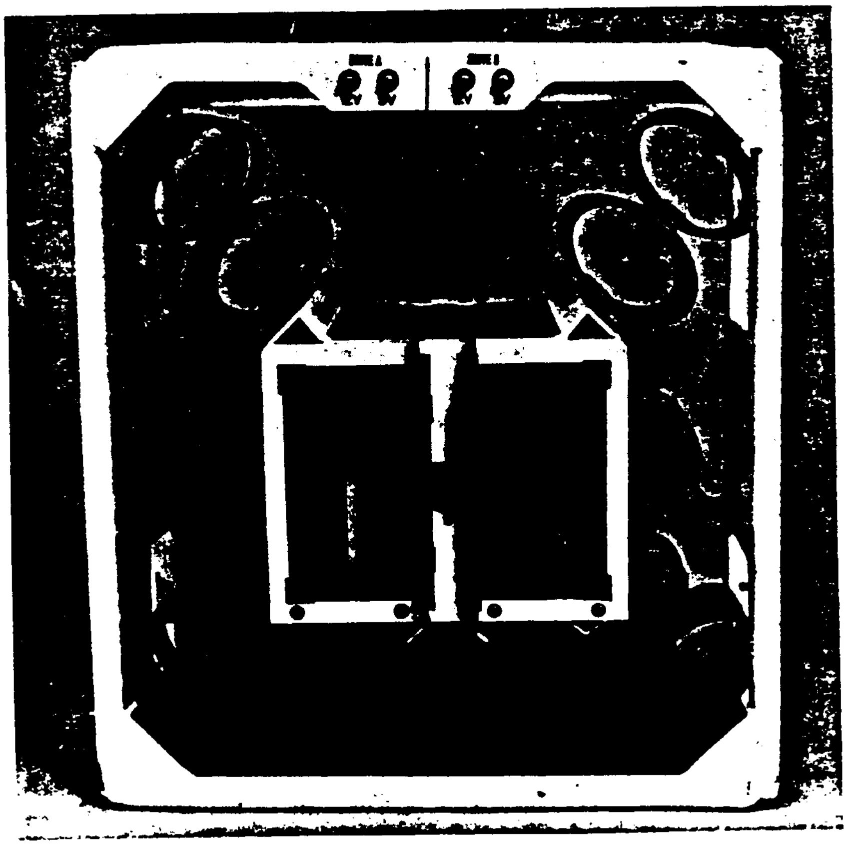

FIGURE 8. Enclosure

2. The government does not control the manufacturer's design department, competition and the market place do. Asking for changes to standard products to meet requirements creates major problems. Every attempt should be made to use the standard product without alteration.

3. Stick with industry accepted interface standards. ***Make sure the standard is accepted and really used fry the industry.*** Do not inject the options in the standard unless they are accepted and available from multiple vendors.

4. Document product baseline and acceptance criteria.

5. Users wanting multiple product sources must design their system architecture to accept alternative products and consider long-term impacts from options provided by the different vendors.

6. Again, try not to tailor the vendor's product. Typically, marking, jumpers, and built-in-test (BITE) are the only elements a vendor will change to meet a specific application.

CASE STUDY 3
Cooperative Engagement Capability (CEC)

This system is a new technology being developed as a wireless network between ships or a battle group at sea to share theater air defense radar information and coordinate engagements of targets among the ships. CEC has implemented an aggressive acquisition reform approach to development and procurement.

Situation:

The CEC program has implemented three major thrusts: acquisition Streaking, transition to "commercial baseline," and commercial off-the-shelf implementation.

The CEC program has been streamlining through the use of government-contractor teaming. An example of this is the teaming of NSWC Crane Division and contractor reliability engineers in the performance of Failure Mode Effectivity Criticality Analyses (FMECA) and Part Stress Analyses. This allows the Navy insight into the contractor's design and reliability groups and assures that an effective process is implemented. Through modern communication, changes and recommendations for improvement are implemented into hardware at the design stage, rather than requiring a lengthy Contract Data Requirements List (CDRL) for the development/review/comment process.

[T]he government equipment engineer cannot have equipment selection based solely upon, or even dominated by, the "low bid."

Another streaming effort is the on-line access into the contractor's design and analysis computer systems which allows the contractor to deliver digital data. NSWC Crane Division engineers may enter the databases, extract information for checking and analysis and formulate comments or suggestions without requiring the contractor to develop a paper CDRL item. During the next contract phase, when delivery is necessary the contractor may supply a soft copy to the government, which can then be placed on a network for access by reviewers. This saves the time and expense of developing, copying, *and* distributing paper CDRL iterns.

The CEC is transitioning to the use of commercial specifications and standards, and to performance-based specifications. The main system specification has been carefully written to be a performance-based specification. The system specification detines the performance and functions the CEC must provide and the environment that the CEC equipment must work in, but, leaves the design implementation to the contractor. Many MIL-SPEC references in the system specification have been replaced by the actual paragraphs that describe the requirements. Only those MIL-SPECS required by ships interfaces (power, water, etc.) and existing systems the CEC must interface with are retained in the system specification. This allows the contractor to select the most cost-effective design methodology.

The use of COTS and NDI is being actively pursued by the CEC program. Currently, the CEC has included COTS products in its Cooperative Engagement Processor (CEP) and is working to increase COTS usage in other CEC equipment. Desired is improvement in survivability, while using Open System Architectures (OSA), satisfying OSA conformance and assuring COTS supportability

With the use of CEC in multiple platforms, the CEC program is investigating the environmental envelope that COTS products must survive and operate under to determine the most cost effective enclosures and packaging concept for the CEC airborne and shipboard systems (Figure 9). Since the system specification defines the system environmental requirements, by determining the COTS environmental capability the environmental requirements for the enclosure and packaging can be fully defined.

solution:

Use of an open system architecture has provided CEC many benefits. CEC has selected the VME standard (internationally accepted) for interconnection of modules on a backplane. This standard provides sufficient throughput, the ability to expand, and the widest availability of standard products, suppliers, and supporting products. Satisfying **the conformance** requirements dictates the selection of products based on the appropriate profile and demands the engineering knowledge to choose compatible products throughout the system life cycle, including the ability to do technology insertion, second sourcing, upgrades, and to use alternate sources for dealing with obsolescence problems. With a growing number of COTS products already deployed and supported in the field, CEC is focusing on test, repair, and upgrade/end-of-life issues in COTS supportability With COTS products it is a given that there will be frequent upgrades and end-of-life concerns. Beyond CEC itself, this is a huge life-cycle cost matter that needs substantial, additional study

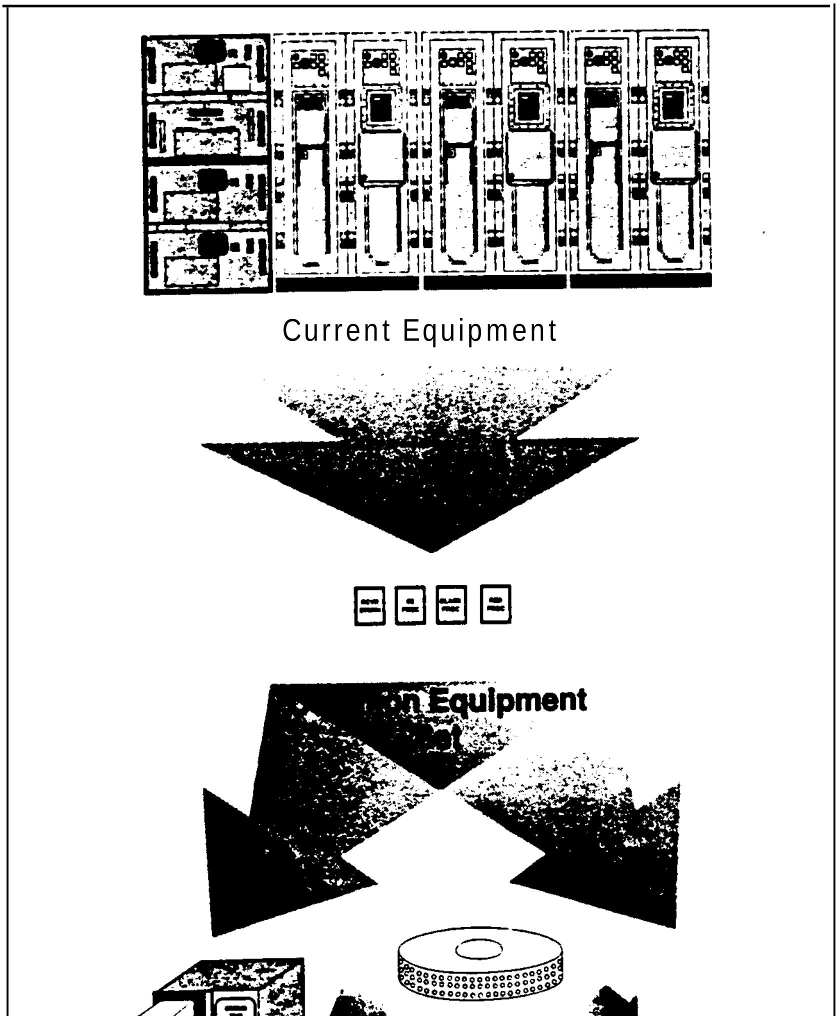

FIGURE 9. CEC

Lessons Learned:

1. Government/contractor teaming reduces paperwork, CDRL items, and cycle times, while improving the design process.

2. switching to performancee-based specifications and commercial standards allows the contractor to develop the system in an economical manner.

3. Enclosures and packaging are probably the best way to mitigate environmental issues with COTS products, but only after the real system requirements are known and the COTS product capabilities are identified.

4. Effective use of an Open System Architecture provides numerous benefits including availability of products, a wide range of suppliers, ability to upgrade, and reduction in design obsolescence risk.

Best Acquisition Engineering Processes (BAEP)

These case studies illustrate that COTS products often can be used successfully in a military environment. The challenge is to provide a framework where lessons learned will not have to be relearned with each initiative and to develop an approved process that provides the same comfort level as military specifications did in the past. This must be done without impeding the use of off-the-shelf products or commercial design and manufacturing techniques. The process used must also ensure that the goals of using appropriate standards, developing an inclusive performance specification, and confirming that the product bought meets the intended mission needs are each consistently satisfied at every application.

To achieve the goal of procuring products more cost effectively from a variety of sources while retaining the confidence formerly derived from military specifications, sound acquisition engineering processes must be applied. These processes must meet the three basic steps previously cited but in a global world of international standards and multiple options so cost can be attained through competition. *Order can* be created out of chaos by looking carefully at the characteristics desired out of this process and the good reasons why "MIL-SPECS" were used so dogmatically Needed are:

- A common rule set upon which industry, acquisition managers, system integrators and oversight bodies, all agree.
- A body of information containing years of lessons learned from acquisition and fleet use. ("MIL-SPECS," though cumbersome, provided this.)
- A vehicle (technique) to describe what is wanted.
- A definition of hardware requirements that establishes product responsibility lines clearly.

The electronic assembly standardization initiative mentioned earlier (SEM) and used for the last 30 years was based upon two assumptions. Market forces can be applied to military procurement and all new products used by the military will be developed for them. Today the latter is not the case. When we apply the desired process goal to the new realities of the international market, we find we can achieve the required outcome but with altered procedures (Figure 10). Through the use of cleverly-designed automation and broad access to up to date, stored information, the new process must provide the desired characteristics in an online and cost-effective manner.

l-he ""specification development" phase must evolve from a dogma-driven process to an interactive one that:

a. Acknowledges the applicable industry standards,
b. Takes into account the available options whether they are non-development items or new developments,
c. Is inherently tolerant to specification of appropriate performance, environmental, and support requirements without demanding unnecessary ones,
d. Is derived from a common set of rules which can be agreed upon by all parties, and
e. Can be automated to be quick and

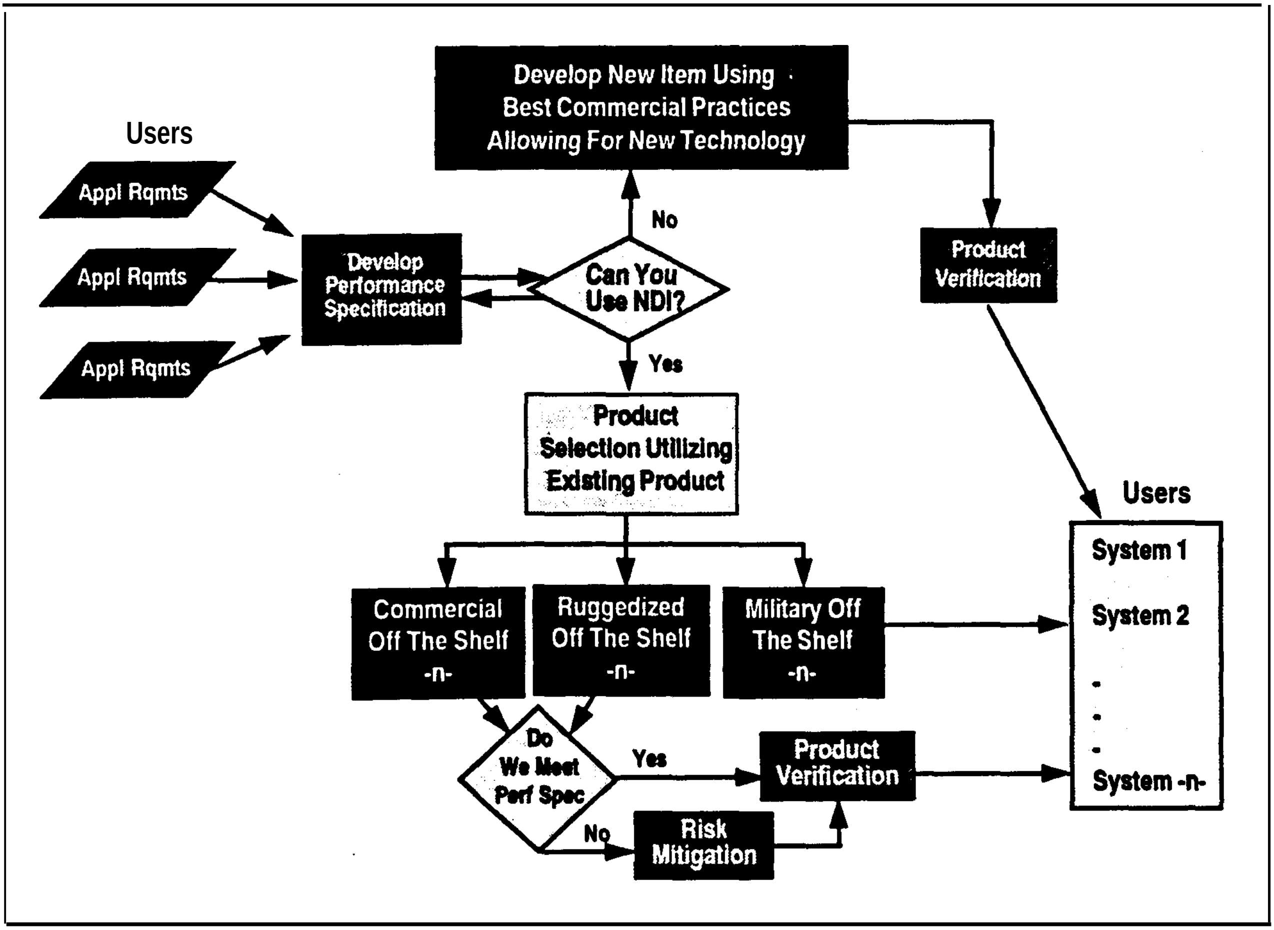

FIGURE 10. New Process

cost effective because product realities require numerous tailored performance specifications (usually labor intensive but susceptible today to iterative procedure).

In sum, the process must be disciplined to include only those "'requirements" that are absolutely necessary to meet operational needs. Overspecifying is unacceptable. But, the underlying axiom fundamental to the American value system must always be served. ***Minimizing loss of life and limb, while winning*** the war, is an essential ingredient in the tools of battle whenever American warriors are asked to defend their country.

The next step in constructing a modem process is handling product selection. This requires good product conversance with the technology and industry options available and must include the understanding that every decision will be a cost, risk, and performance trade off. The appropriate choice must be made consciously on a case by case basis. Although this sounds intricate and complex, when you get to the product level, as in disk drives, there are a limited number of manufacturers and technical options to be analyzed by knowledgeable product engineers. Based upon requirement and product analysis, a prudent decision can be made on the best approach, whether it is a nondevelopment item or a custom design using commercial practices. In a support role, technology tools such as modern simulation techniques can also be used (within their range of validity) to explore varied design options with their concomitant cost/performance implications. Trade-offs among commercial components vs. military-unique hardware can be identified and gauged for acceptability using such techniques. Always to be remembered is the observation that "one size does not fit all."

To assist in using best commercial practices, a partnering with industry is essential. This assures appropriate interface and manufacturing standards are used and that the design practices pursued are in line with the industry direction.

Implementing with a nondevelopment item means the selection process covers a broader scope. The availability of products which cart be integrated into military systems from "open" sources is enormous. These products can take the form of:

- commercial off-the-shelf (COTS). those items which are developed for commercial environments.
- ruggedized off-the-shelf (ROTS), those items developed for strenuous commercial environments.
- militarized off-the-shelf (MOTS). those products available from other military developments (not just U.S.),

The appropriate choice is then a cost, risk, availability and suitability tradeoff. A COTS product, for example, may have *a* lower acquisition cost but a higher implementation cost. Regardless of the options, however, sound product engineering must be applied, and the main question remains: does it meet the performance requirements?

Lawyers, MBA's and political scientists are hard to find when system design decisions have to be made and they are nowhere to be found when accountability for performance is assigned.

If not, mitigation techniques can be applied. Many products, through environmental isolation or other ameliorative techniques, can be used in military systems. The techniques vary with product capabilities and end use restrictions. The key to effectively implementing these techniques is to apply existing successful approaches others have already used to solve similar problems. Such discovery can range from general information to "ingenious" devices or even actual products that can be applied, e.g., enclosures. The modern process constructed will establish a "living catalog" of success paths that have been found to assure "good fit" solutions and that facilitate matching a new hardware question with a feasible answer. Engineering then takes over to produce the optimum result.

If a product is used "as is," or has a mitigation technique applied, it must then be subjected to a product verification phase which ensures that it meets the intended application. Product verification has to be rooted in reality. Inevitably the worst possible conditions imaginable can form the operational environment at the outbreak of hostilities, loss or partial loss of supporting equipment can often occur as well, and hardware degradation can also be experienced prior to or during active engagement. Performance data reflecting these cruel, probabilistic circumstances need empirical validation. Depending upon the product and the particular requirement the verification can come from simulation results, actual testing or knowledge obtained from prior use. The key is understanding which option applies to particular product requirements. The product verification and product specification phases must be integrally linked. The burden upon engineering professionals for continued excellence is eminently clear.

The outcome of this overall process is a product that can be used in military systems. If we integrate our knowledge base of requirements, applicable products, product verification, and lessons learned, the combination can be leveraged upon in other applications. The "secret" is having a product acquisition process based upon sound product engineering fundamentals. This process must provide focus to information distribution through a common set of ground rules that facilitate implementation. The process must take into account the realities of the market place and yet be inherently flexible while, simultaneously, providing sustainable and reliable systems for the Fleet whether destined for combat systems or huff, machinery electrical (H, M&E) use. Seasoned engineers know *using* handbooks or other dogma is not sufficient but using knowledgeable, technically astute professionals thoroughly familiar with engineering design issues, the existing marketplace and empirical data, is.

In satisfying DoD requirements, in general, and derivative Navy-wide needs, in particular, it is again worth noting that the general DoD Standardization Program is over forty years okf and did its job quite well during that interval. It reduced an unnecessary multiplicity of items, encouraged national standards and helped assure quality of purchased material. Indeed, DoD procedures, in essence, defined the state of the art at the time. Today, matters are changed but those same product engineering principles are behind *Best* ***Acquisition Engineering Processes (BAEP), see*** Figure 11. The application of these principles assures delivery of performance-based products into the design process. That means validated products from the commercial marketplace, selected by knowledgeable engineers, can be supplied to the Fleet.

CONCLUSIONS

The Navy acquisition community must set forth a central theme and associated training plan to support individual Navy hardware programs in implementing specification and standardization reform. It is essential that all hands understand, respect and actively participate in the changed view of defense acquisition that is now required to meet national needs. A sea change in outlook is necessary as we shift from a stance of risk avoidance, which has been the approach for some fifty years, to a stance of risk management, a path more aligned with and appropriate to our time and budgets. Seminars, courses and specific classroom training materials must be developed to facilitate transfer and assimilation of the new acquisition reform procedures and encourage new mindset. Doing this constructively

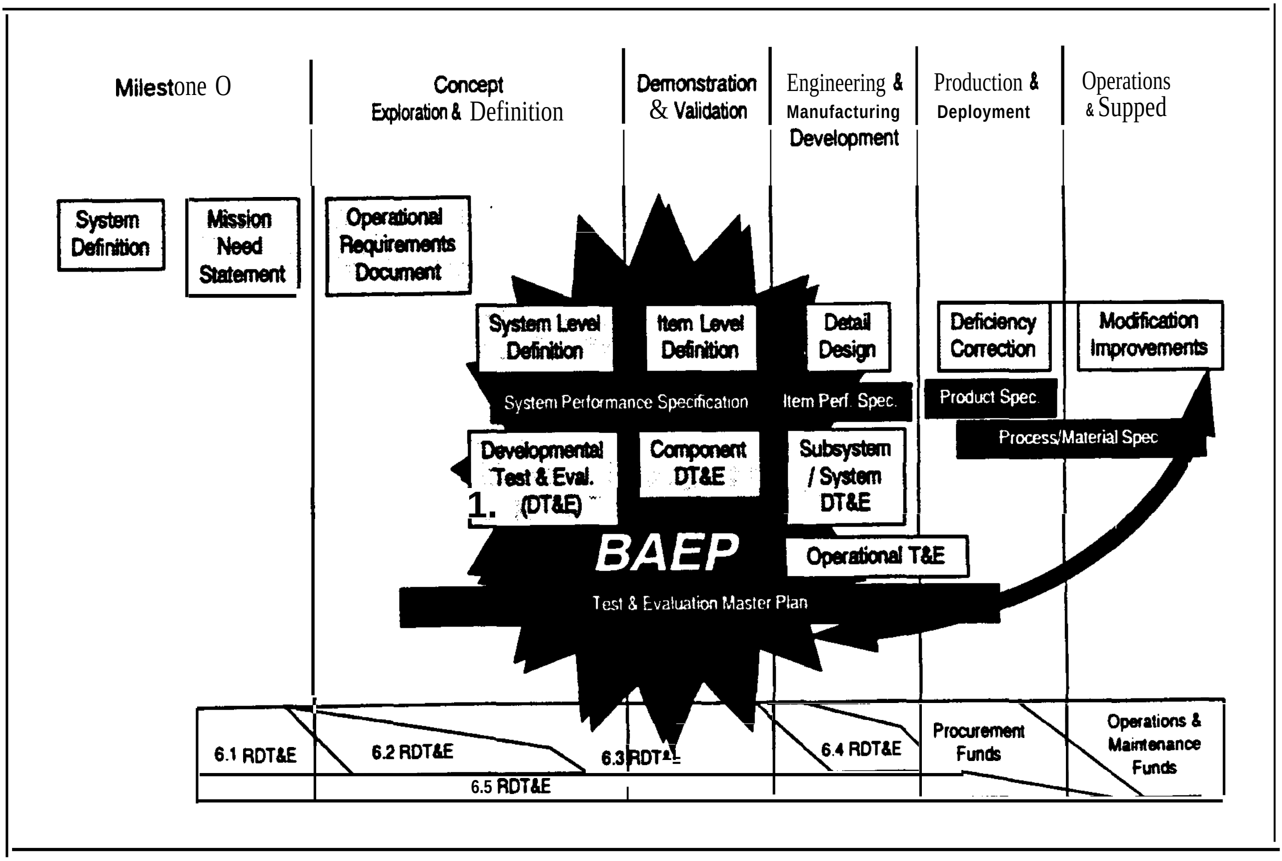

FIGURE 11. Systems **Engineering/Test &** Evaluation

and without silly, inflexible doctrine inserted is not simple.

Monitoring procedures and "how goes it" reporting are essential to assure management progress, relevant guidance and workforce adherence. Choosing alternative paths to what has been classical use of military specifications and standards cannot occur without direct involvement of supervisors and line personnel playing a leadership role. Since each local command exercises substantial autonomy over standardization decision making it is mandatory that a "can do" attitude be exercised from above if there is any hope for change throughout the workforce. The opportunity for useful, practical impact upon the military market is possible. Uncontrolled pursuit of extravagant objectives, however, particularly when applied to inappropriate military materiel, brings its own share of downsides. In short, complete civil-military integration cannot be expected in every military sector essential to winning wars. We need superior technical talent with product engineering experience at the decision pulse points to tell the difference between the feasible and the fanciful. In rendering these technical judgements, the industry-government acquisition engineering team must control the decisionmaking for the products being designed and procured. Common, coordinated support to individual program managers is required. Not needed are blanket demands from above for meeting universally applied standards that disregard specific Navy system design requirements.

The paper has not dealt with the significant issue of liability since it is well beyond the scope of engineering discussion. MIL SPECS were developed over many years to reflect government liability and accountability for failure in battle. To the question, "Who is liable for a failure of a COTS item and consequent loss of life and limb?" the response would appear still to be: the govemrnent. But if thiS is so, it would seem that government engineers must have knowledge of many equipment characteristics commercial industry would claim as proprietary. If systems in USS *Vincennes*, "USS *Saratoga*, or the helos in Iraq were COTS, who would certify at the public investigation that they met system integrity safety and interoperability "standards?" The selling companies? What does this mean m military and international faw? Are such questions academic because once the government decides to make a purchase that decision itself confers an "acceptance blessing" equivalent to a former MIL SPEC buy? Such issues must be resolved as we proceed along changed procurement paths in Navy system acquisition.

Computer processors and displays are susceptible to progressive change but high thrust rocket motors, nuclear power, HY-100 steel and anti-armor warheads need very careful consideration.

The observation was made early in the paper that a process (SHP-SEM) has existed for 30 years to control uniformity in electronic hardware. The new wave of acquisition reform and the realization that the DoD marketplace no longer dominates many forms of technology development gives rise to a necessity for change. Given the truth of the recurrent criticisms laid on many of our existing acquisition procedures can the fresh concepts offered up as answers in the new acquisition policy ***actually be implemented?*** When the accountants, lawyers, politicians and purchasing agents step back from the lectern is there a feasible solution space in which engineers can work, accomplish necessary results and deliver acceptable products? Is there any previous applicable experience dealing with orderly procurement of engineering design, manufacture, delivery and operational use of components and equipment bought for military systems? Can all this be done without disruptive and costly management intrusion? The answers to these questions (at least for the acquisition of electronic or similar hardware) is, YES, and the process ***is envisioned*** as described: ***Best Acquisition Engineering Processes (BAEP).*** BAEP is a modification of a successful, tested procedure. Not a panacea, not a late-breaking fad, but a practical process, hardened and tempered in the cauldron over many years of use, just under different circumstances. Now it is being called forth, transformed and strengthened to support fresh solutions to new problems in a changed world. ✤

REFERENCES

[1] SecDef kr (W. J. Perry); Specifications and Standards-A New Way of Doing Business dtd 29 June 1994.

[2] Report of the Process Action Team on Military Specifications and Standards, Blueprint for Change, April 1994, p. 19.

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